(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 555 470 A1

(12) # EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC

(21) Application number: 90916074.9

(22) Date of filing: 02.11.90

(86) International application number: PCT/JP90/01426

(87) International publication number: WO 92/08333 (14.05.92 92/11)

(51) Int. Cl.5: H05B 33/14, H05B 33/18, H05B 33/22

(43) Date of publication of application: 18.08.93 Bulletin 93/33

(84) Designated Contracting States: DE FR GB NL

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(54) ## THIN-FILM EL ELEMENT.

(57) An improved thin-film EL element that exhibits electroluminescence in response to the application of an electric field, that maintains high brightness over a long period, and that exhibits improved brightness in blue display. A light-emitting layer (4) is made of a sulfide of an alkaline earth metal as the base material, and insulating layers (3) and (5) in contact with the light-emitting layer (4) are made of a sulfate or a carbonate of an alkaline earth metal. Further, the light-emitting layer (4) contains Ce as luminescence center in the base material of SrS and is doped with Pb as a coactivator.

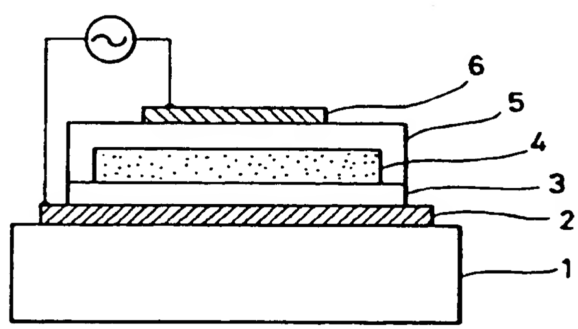


FIG. I

Technical Field

The present invention relates to a modification of a thin film EL device for performing an EL emission according to an electric field being applied, in particular, to a thin film EL device for providing a stable luminance for a long time and for improving the luminance of a blue color display.

Related Art

So far, various studies have been conducted for multi-color thin film EL devices. As basic materials for light emission layers, strontium sulfide (SrS) and calcium sulfide (CaS), which are sulfides of alkaline earth metals, are used. To cause such thin film EL devices to stably emit visible light, a suitable interface should be formed between a light emission layer and insulation layers which sandwich the light emission layer. To do that, a device having insulation layers composed of a nitride such as Si_3N_4, AlN, or BN has been proposed as disclosed in for example Japanese Patent Laid-open Publication Serial No. SHO 62-5596.

However, even if the above-mentioned thin film EL device which has insulation layers composed of a nitride is used, SrS or CaS as the basic material of the light emission layer is reacted with moisture, CO_2, and so forth contained in air. Thus, an oxide (such as SrO and CaO) or a carbonate (such as $SrCO_3$ and $CaCO_3$) partially takes place, which results in aged deterioration of the light emission layer of the device. Thus, the luminance of the EL device diminishes in a short time.

In addition, as a light emission layer for a conventional blue color display thin film EL device, SrS:Ce or ZnS:TmF_3 has been used.

However, although the light emission layer which is composed of SrS:Ce has the highest luminance in blue color display thin film EL devices, when a sine wave of 5 kHz is applied to the light emission layer, the luminance thereof is at most 1000 cd/m^2. When this device is used for a dot matrix display which is driven at 60 Hz, luminance of 20 to 30 cd/m^2 is required. Nevertheless, the maximum luminance of the device which is composed of SrS:Ce is at most 10 cd/m^2, which is 1/2 to 1/3 times that of the required luminance.

The present invention is made from the above-mentioned point of view. An object of the present invention is to provide a thin film EL device for continuously furnishing stable luminance for a long time and for enhancing the luminance of blue color display at least two to three times that of the conventional devices.

Disclosure of the Invention

The present invention is a thin film EL device, comprising

a pair of opposed electrodes and a laminate composed of a light emission layer and an insulation layer, wherein the light emission layer is composed of a sulfide of an alkaline earth metal as a basic material, and wherein at least the insulation layer disposed adjacent to the light emission layer is either the sulfide or a carbonate of the alkaline earth metal.

Between the insulation layer and the electrodes, another insulation layer composed of Ta_2O_5, SiON, or SiN:H may be disposed.

The light emission layer is composed of Ce as a basic material and Pb of 1 at % or less as a coactivator being doped.

According to the above-mentioned construction, since insulation layers are composed of a sulfate or a carbonate of an alkaline earth metal, which is a stable compound, they are not adversely affected by moisture, CO_2, and so forth contained in air. In addition, since the insulation layers contain the same element as the light emission layer whose basic material is a sulfide of an alkaline earth metal, a suitable interface can be formed, thereby preventing aged deterioration of the light emission layer.

Moreover, according to the present invention, Ce as a light emission substance is used and Pb of 1 at % (atomic %) as a coactivator is added thereto along with SrS as the basic material, thereby SrS:Ce, Pb is formed. Thus, besides the conventional excitation of Ce, there is another excitation due to an energy transmission from excited Pb to Ce. Therefore, the probability of excitation of the present invention is higher than that of the conventional SrS:Ce. In addition, since the light emission band of Pb is close to the light absorption band of Ce, energy is effectively transmitted from Pb to Ce. Thus, the luminance of the present invention is higher than that of the conventional devices which are composed of SrS:Ce.

Brief Description of Drawings

Fig. 1 is a schematic diagram showing the construction of a thin film EL device according to a first embodiment of the present invention;

Fig. 2 is a schematic diagram showing the construction of a thin film EL device according to a second embodiment of the present invention;

Fig. 3 is a graph showing a characteristic of luminance vs. added amount of Pb to a sine wave at 1 kHz of a blue color display thin film EL device according to a third embodiment of the present invention; and

Fig. 4 is a graph showing comparison between the third embodiment and a conventional blue color display device for a characteristic of luminance vs. voltage to a sine wave at 1 kHz.

Best Modes for Carrying out the Invention

With reference to the accompanying drawings, preferred embodiments of thin film EL devices according to the present invention are described.

Fig. 1 is a schematic diagram showing a thin film EL device according to a first embodiment. Over a glass substrate 1, a transparent electrode 2 composed of such as In_2O_3 or SnO_2 is formed. Over the transparent electrode 2, a first insulation layer 3 is laminated by for example sputtering method. The first insulation layer 3 is composed of such as $SrSO_4$ or $SrCO_3$, which is a sulfide or a carbonate of an alkaline earth metal. Over the first insulation layer 3, a light emission layer 4 is formed by for example vacuum evaporation method. The light emission layer 4 is composed of SrS as a basic material and Ce and Cl as light emission substances. Thus, the light emission layer 4 is composed of SrS:Co, Cl. Over the light emission layer 4, a second insulation layer 5 and a metal electrode 6 are formed in succession. The second insulation layer 5 is composed of for example $SrSO_4$ or $SrCO_3$. $SrSO_4$ is the same compound contained in the first insulation layer 3.

Fig. 2 is a schematic diagram showing the construction of a thin film EL device according to a second embodiment of the present invention. In this embodiment, over a glass substrate 1, a transparent electrode 2 is formed. The transparent electrode 2 is composed of for example In_2O_3 or SnO_2. Between the transparent electrode 2 and a first insulation layer 3, an insulation layer 3a is formed. In addition, between a second insulation layer 5 and a metal electrode 6, an insulation layer 5a is formed. The insulation layers 3a and 5a are composed of for example Ta_2O_5, SiON, or SiH:H. Thus, in the second embodiment, a plurality of insulation layers are formed.

In each of the above-mentioned embodiments, the light emission layer which is composed of a sulfide of an alkaline earth metal as a basic material is sandwiched with the insulation layers composed of a sulfide or a carbonate of an alkaline earth metal. In these embodiments, as the light emission substance of the light emission layer, Ce and Cl were used. However, it should be noted that the present invention is not limited to such composition. Rather, other additives can be selectively used according to light emission colors.

As described above, since the above-mentioned stable compound is used for the insulation layers, it is not affected by moisture, CO_2, and so forth contained in air. Thus, the device can be prevented from aged deterioration. In addition, since the insulation layers contains the same element as the light emission layer, a suitable interface can be formed. Thus, the light emission layer can furnish stable luminance for a long time.

Next, a third embodiment according to the present invention is described. In this embodiment, SrS is used as a light emission basic material of a thin film EL device. As a light emission substance, Ce is used. In addition, as a coactivator, Pb is used. In this embodiment, five types of blue color display thin film EL devices were produced. In this embodiment, the added amount of Pb was changed, whereas Ce was fixed to 0.1 at %. As the added amounts of Pb (at %), 0.1, 0.2, 0.3, 0.4, and 1.7 were selected. In this embodiment, a sine wave of 1 kHz was applied to these devices and the luminance of these devices were measured. In addition, the luminance of the conventional blue color display thin film EL device composed of SrS as a light emission basic material and Ce of 0.1 at % as a light emission substrate was measured. Fig. 3 shows the comparison results of these devices. Thus, in comparison with the conventional device (namely, Pb = 0 at %), as the added amount of Pb increases, the luminance strengthens. In the case of Pb = 0.3 at %, at L30 where the drive voltage rises by 30 V from light emission start voltage, the luminance is approximately tripled. At L60 where the drive voltage rises by 60 V from the light emission start voltage, the luminance is approximately doubled.

When at % of Pb exceeds 0.3, the luminance at both the L30 and L60 lowers. When at % of Pb is 1.7, the luminance is lower than that of the conventional device. Thus, it is preferred that at % of Pb should be 1 or less.

Fig. 4 is a graph showing comparison between the third embodiment and a conventional blue color display device for a characteristic of luminance vs. voltage to a sine wave at 1 kHz. The device according to the present invention is composed of SrS:Ce, Pb where at % of Ce is 0.1 and at % of Pb is 0.3. The conventional device is composed of SrS:Ce where at % of Ce is 0.1. As shown in the figure, according to the blue color display thin film EL device of the present invention, the luminance at 180 V (at L30 where the drive voltage rises from the light emission start voltage of 150 V by 30 V) is three times higher than that of the conventional device. The luminance at 210 V (at L60 where the drive voltage rises from of the light emission start voltage of 150 V by 60 V) is twice higher than that of the conventional device.

As described above, since the light emission layer of the present invention is composed of SrS:Ce, Pb, the luminance thereof strengthens by

twice to three times that of the conventional device which is composed of SrS:Ce. Thus, the device according to the present invention can satisfy the required luminance for a dot matrix display. In addition, the luminance of the device can be sharply proportional to the voltage.

Industrial Utilization

The present invention is useful for a thin film EL device which can furnish stable luminance for a long time. When the device according to the present invention as a blue color display thin film EL device is used for a dot matrix display, luminance of at least 20 to 30 cd/m^2 can be obtained.

Claims

1. A thin film EL device, comprising:
   a pair of opposed electrodes; and
   a laminate composed of a light emission layer and an insulation layer,
   wherein said light emission layer is composed of a sulfide of an alkaline earth metal as a basic material, and
   wherein at least said insulation layer disposed adjacent to said light emission layer is either said sulfide or a carbonate of said alkaline earth metal.

2. The thin film EL device as set forth in claim 1, further comprising:
   a second insulation layer composed of for example Ta_2O_5,SiON, or SiN:H, said second insulation layer being disposed between each of said electrodes and said insulation layer.

3. A thin film EL device, comprising:
   a pair of opposed electrodes; and
   a laminate composed of a light emission layer and an insulation layer,
   wherein said light emission layer is composed of SrS as a light emission substance, Ce as a light emission substance, and Pb as a coactivator being doped.

4. The thin film EL device as set forth in claim 3,
   wherein the added amount of Pb as said coactivator is 1 at % or less.

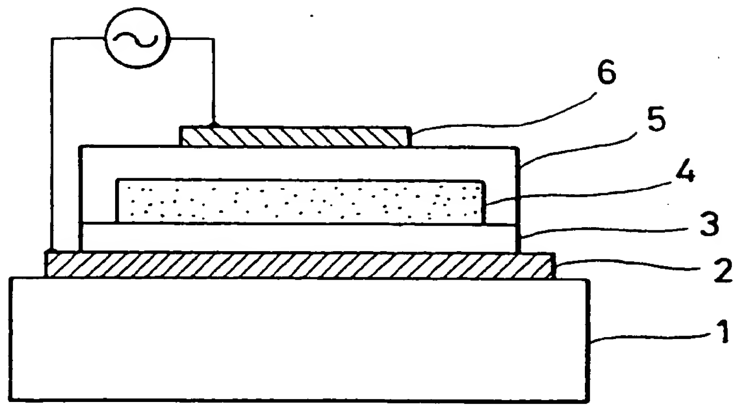


FIG. 1

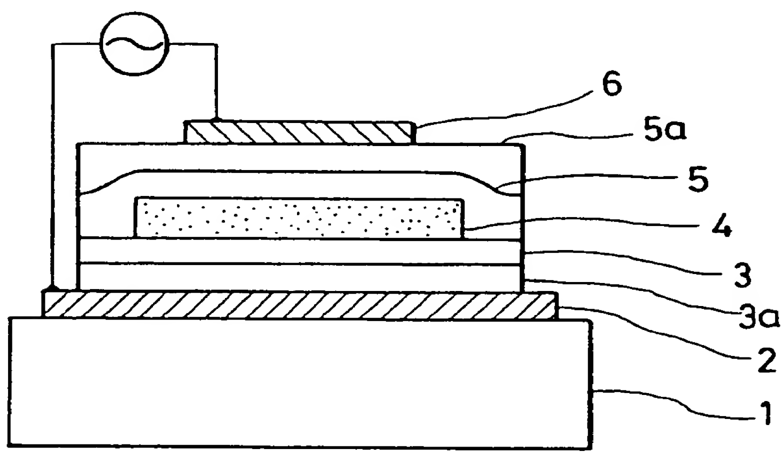
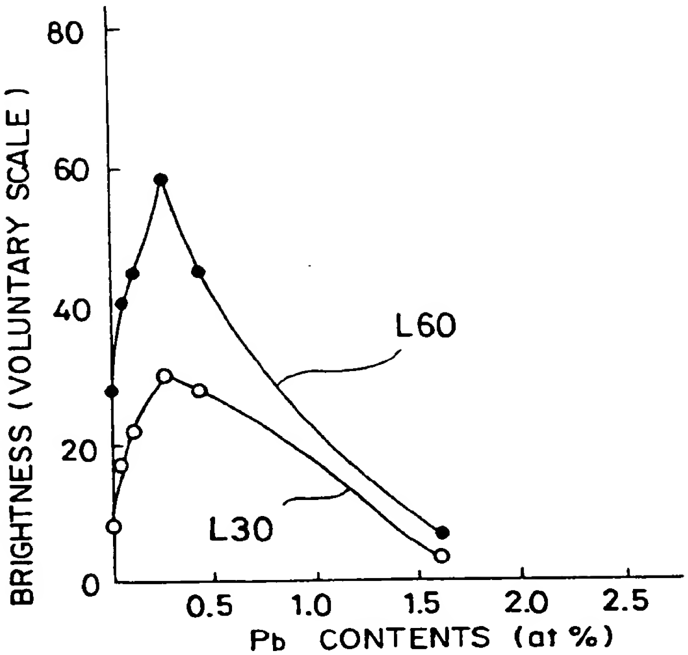
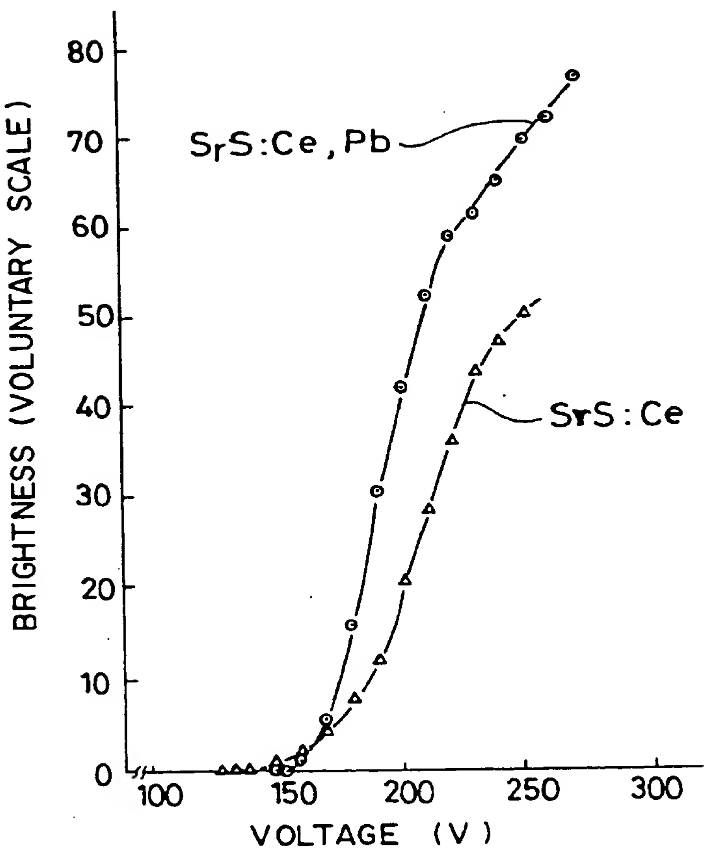


FIG. 2



80
60
40
20
0
BRIGHTNESS (VOLUNTARY SCALE)
L60
L30
0.5
1.0
1.5
2.0
2.5
Pb CONTENTS (at %)

FIG.3



80
70
60
50
40
30
20
10
0
BRIGHTNESS (VOLUNTARY SCALE)
SrS:Ce, Pb
SrS:Ce
100
150
200
250
300
VOLTAGE (V)

FIG.4

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/01426

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 H05B33/14, H05B33/18, H05B33/22

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H05B33/14, H05B33/18, H05B33/22

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1989
Kokai Jitsuyo Shinan Koho	1971 - 1989

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	JP, A, 61-121290 (Matsushita Electric Ind. Co., Ltd.), June 9, 1986 (09. 06. 86), Line 11, lower left column, page 2 to line 7, upper left column, page 3 (Family: none)	1, 2
Y	JP, A, 62-5596 (Sharp Corp.), January 12, 1987 (12. 01. 87), Line 16, lower left column, page 2 to line 5, upper left column, page 3 & EP, A1, 189,157 & US, A, 4,717,858	1, 2
A	JP, A, 58-125781 (Hitachi, Ltd.), July 26, 1983 (26. 07. 83), Line 11, lower left column to line 20, upper right column, page 3 (Family: none)	3, 4
Y	JP, A, 01-100892 (Komatsu Ltd.), April 19, 1989 (19. 04. 89), Lines 5 to 11, lower left column, page 1 (Family: none)	3, 4

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
January 16, 1991 (16. 01. 91)	January 28, 1991 (28. 01. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	